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Regional Peer Review Process on a Risk-based Assessment Framework to Identify Priorities for Ecosystem-Based Oceans Management in the Pacific Region

Cadre d'évaluation fondé sur les risques visant à déterminer les priorités pour la gestion écosystémique des océans dans la région du Pacifique

May 8-10, 2012

Pacific Biological Station
Nanaimo, British Columbia

Meeting Chairperson:
John Holmes

Rapporteurs:
Jessica Finney
Julie-Beth McCarthy

Du 8 au 10 mai 2012

Station de biologie du Pacifique
Nanaimo, Colombie-Britannique

Président de la réunion:
John Holmes

Rapporteures:
Jessica Finney
Julie-Beth McCarthy

Fisheries and Oceans Canada / Pêches et Océans Canada
Science Branch / Secteur des Science
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

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Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings include research recommendations, uncertainties, and the rationale for decisions made by the meeting. Proceedings also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

Avant-propos

Le présent compte rendu a pour but de documenter les principales activités et discussions qui ont eu lieu au cours de la réunion. Il contient des recommandations sur les recherches à effectuer, traite des incertitudes et expose les motifs ayant mené à la prise de décisions pendant la réunion. En outre, il fait état de données, d'analyses ou d'interprétations passées en revue et rejetées pour des raisons scientifiques, en donnant la raison du rejet. Bien que les interprétations et les opinions contenues dans le présent rapport puissent être inexactes ou propres à induire en erreur, elles sont quand même reproduites aussi fidèlement que possible afin de refléter les échanges tenus au cours de la réunion. Ainsi, aucune partie de ce rapport ne doit être considérée en tant que reflet des conclusions de la réunion, à moins d'indication précise en ce sens. De plus, un examen ultérieur de la question pourrait entraîner des changements aux conclusions, notamment si l'information supplémentaire pertinente, non disponible au moment de la réunion, est fournie par la suite. Finalement, dans les rares cas où des opinions divergentes sont exprimées officiellement, celles-ci sont également consignées dans les annexes du compte rendu.

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K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/

CSAS-SCCS@DFO-MPO.GC.CA

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting on May 8-10, 2012, at the Pacific Biological Station in Nanaimo, British Columbia. One working paper was presented for peer review. This paper developed an ecological risk assessment framework to identify and assess the relative risk of harm to VECs from human activities and their associated stressors and to rank the significance of activities and stressors based on the relative risks to VECs.

In-person and web-based participation included DFO Science, Fisheries and Aquatic Management Sectors staff; and external participants from First Nations organizations, the Province of British Columbia, Environment Canada, the United States National Oceanic and Atmospheric Administration (NOAA), the commercial fishing sector, environmental non-governmental organizations, consultants, and academia.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report to Oceans and Ecosystem Management to inform the development of conservation objectives for the Pacific North Coast Integrated Management Area (PNCIMA) and Pacific Region Marine Protected Areas (MPAs).

The Science Advisory Report and supporting Research Document will be made publicly available on the CSAS Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm

SOMMAIRE

Ce compte-rendu résume les principales discussions et conclusions qui découlent de la réunion d'examen régional par les pairs du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada qui s'est tenue du 8 au 10 mai 2012 à la Station biologique du Pacifique de Nanaimo, en Colombie-Britannique. On a présenté un document de travail aux fins d'examen par les pairs. Ce document contient un cadre d'évaluation du risque pour l'environnement visant à déterminer et à évaluer le risque relatif de dommages causés aux composantes valorisées de l'écosystème (CVE) par les activités humaines et les agents de stress connexes, ainsi qu'à classer l'importance des activités et des agents de stress en fonction des risques relatifs pour les CVE.

Au nombre des participants qui ont assisté à la réunion en personne ou par conférence Web, il y avait notamment des représentants des secteurs des Sciences et de la Gestion des pêches et de l'aquaculture (GPA) du MPO ainsi que des représentants d'organisations des Premières Nations, de la province de la Colombie-Britannique, d'Environnement Canada, du National Oceanic and Atmospheric Administration des États-Unis, du secteur de la pêche commerciale, d'organisations non gouvernementales vouées à l'environnement et du milieu universitaire, ainsi que des consultants.

Les conclusions et les avis découlant de cet examen seront fournis sous forme d'un avis scientifique à la Gestion des océans et des écosystèmes afin de guider l'élaboration d'objectifs de conservation pour la zone de gestion intégrée de la côte nord du Pacifique et les zones de protection marine de la région du Pacifique.

L'avis scientifique et le document de recherche à l'appui seront rendus publics sur la page du calendrier des avis scientifiques du SCCS à http://www.dfo-mpo.gc.ca/csas-sccs/index-fra.htm.

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer-Review Process (RPR) meeting was held on May 8-10, 2012, at the Pacific Biological Station in Nanaimo to review an ecological risk-based assessment framework (ERAF) designed to identify and rank the relative risk of harm to valued ecosystem components (VECs) from human activities and associated stressors in order to inform the development of conservation objectives in the Pacific North Coast Integrated Management Area (PNCIMA) and Pacific Region marine protected areas (MPAs).

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from the Ecosystem Management Branch of DFO. Notification of the science review and conditions for participation were sent to appropriate DFO staff and external representatives with relevant expertise from First Nations, the Province of BC, Environment Canada, the United States National Oceanic and Atmospheric Administration, the commercial fishing sector, environmental non-governmental organizations, consultants, and academia.

The following working paper was prepared and made available to meeting participants for their review prior to the meeting:

> An Ecological Risk Assessment ERAF (ERAF) for Ecosystem-based Oceans Management by Miriam O, Rebecca Martone, Lucie Hannah, Lorne Grieg, Jim Boutillier and Sarah Patton. (CSAP WP2012-P46).

The meeting Chair, John Holmes, welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chair discussed the role of participants, the purpose of the various RPR publications (Science Advisory Report, Proceedings and Research Document), and the definition and process around achieving consensus decisions and advice. Everyone attending in person and via webinar was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the Terms of Reference, agenda, and working paper.

The Chair reviewed the Agenda (Appendix B) and the Terms of Reference for the meeting, highlighting the objectives and identifying the expected products from the review. The Chair then reviewed the ground rules and process for information exchange, reminding participants that the meeting was a science review and not a consultation. The room was equipped with microphones to allow remote participation by web-based attendees, and in-person attendees were asked to address comments and questions so they could be heard by those online.

Participants were reminded that everyone at the meeting had equal standing and that they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. In total, 62 people participated in the RPR (Appendix C). Jessica Finney (DFO Science) was identified as the lead Rapporteur for the meeting and was assisted by Julie-Beth McCarthy (DFO Oceans).

Participants were informed that Jameal Samhouri (external), Phil Levin (external) and Laura Park (internal) were asked before the meeting to provide written reviews of the working paper to assist in shaping, but not limiting, discussion by participants attending the peer-review meeting. Both Jameal Samhouri and Laura Park were present at the meeting and presented their reviews in person. Phil Levin was unable to attend in person or via webinar and his review was read by the Chair, John Holmes. The working paper authors were provided with copies of the reviews in

advance of the meeting so that they were prepared to respond to the issues raised by the reviewers. Meeting participants were also provided with copies of the written reviews in advance of the meeting.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report to Ecosystem Management to inform the implementation of DFO's ecosystem-based oceans management in PNCIMA and Pacific Region MPAs. The Science Advisory Report and supporting Research Document will be made publicly available on the CSAS Science Advisory Website at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm

FRAMEWORK CONTEXT

Kate Ladell (DFO Oceans) and Hilary Ibey (DFO Oceans) provided a presentation of the context for the original request for Science advice. Canada's *Oceans Act* guides DFO to employ a precautionary integrated whole ecosystem approach to management. However, to date there is no formalized process to develop clear conservation objectives (COs) for marine protected areas (MPAs). Historically, COs have been written to protect intangibles such as biodiversity and ecosystem functions. However, those objectives do not provide clear conservation direction. In order to effectively implement ecosystem-based management, managers need a rigorous, defensible approach that produces specific, measurable, achievable, realistic and time sensitive (SMART) objectives. COs should capture managed and unmanaged human impacts (including cumulative effects), ecosystem state, background variability, and impact thresholds for VECs. The approach to developing COs needs to be scalable to accommodate applications to MPAs of varying geographic sizes as well as the larger scale of the PNCIMA.

The development of the PNCIMA management plan is following an ecosystem-based management framework. As a part of this framework, PNCIMA managers will be using a risk-based approach to planning, which will assist in the development of a list of priorities for action. The current paper was requested to provide a decision support tool that will allow managers to rank the risk to VECs from both individual stressors and cumulative impacts from multiple stressors. As the management plan is implemented managers will need to monitor and evaluate its implementation, and adapt as necessary.

Discussion following the presentation clarified that the focal point of the current CSAP process was the science analysis ERAF and not the socio-economic components of DFO's implementation of ecosystem-based oceans management in Pacific Region. The authors were asked to focus on science-based VECs of ecological significance and the relative risk of harm to those VECs from human activities and stressors. Socio-economic considerations were beyond the scope of the request for advice because these issues are evaluated separately in DFO's development of an ecosystem-based oceans management framework in Pacific Region. However, it was noted that some socio-economic considerations may be indirectly taken into account when identifying VECs, as VECs could be defined with respect to socio-economic considerations of value to humans.

REVIEW OF WORKING PAPER

Working Paper: O, M., R. Martone, L. Hannah, L. Grieg, J. Boutillier and S. Patton. 2012. An Ecological Risk Assessment ERAF (ERAF) for Ecosystem-based Oceans Management. CSAP WP2012-P46.

WORKING PAPER SUMMARY

The working paper was presented by two of the authors, Miriam O and Rebecca Martone. Their presentation outlined a hierarchical ecological risk assessment framework (ERAF) to support ecosystem-based management (EBM) efforts in the Pacific Region applicable to both the Pacific North Coast Integrated Management Area (PNCIMA) and Marine Protected Areas (MPAs). The ERAF addresses a need for a systematic, science-based and defensible risk-based decision making structure to help guide the transition from high-level aspirational principles and goals to more tangible and pragmatic objectives, strategies and actions that can be implemented in these areas. The authors emphasized that the proposed ERAF does not intend to 'reinvent the wheel', but instead builds upon methodology from existing ecological risk assessment frameworks. The proposed ERAF has been structured utilising methodology from several existing processes including the Australian Ecological Risk Assessment for the Effects of Fishing (ERAF) and ERAFs developed for other DFO Large Ocean Management Areas (LOMAs) amongst others. Adapting methodology from these processes has allowed the creation of an ERAF more specifically tailored for the goals and purposes of EBM in the Pacific Region. The methodology and background to the proposed ERAF were described. The ERAF involves a scoping phase, followed by a risk assessment phase, with three increasingly quantitative levels of risk assessment. The ERAF provides methods for calculating risk to an ecosystem, but more importantly offers the steps necessary to provide transparent and defensible science-based advice on anthropogenic impacts for ecosystem-based management. The authors discussed how the ERAF could be used to inform management activities.

WRITTEN REVIEWS

Laura Park

This section provides an overview of discussion regarding the written review provided by Laura Park prior to the meeting (Appendix D) and documents all decisions/agreements to amend the working paper based on this discussion.

Ms. Park began her review with a description of the Newfoundland experience with classifying Valuable Ecosystem Components (VECs). In early 2007 DFO Science identified 10 Ecologically and Biologically Significant Areas (EBSAs) and 94 VECs within the Placentia Bay/Grand Banks Large Ocean Management Area (LOMA). Although these components were identified, they were not ranked or prioritized by DFO Science. Consequently, DFO Oceans conducted an informal review of 59 high and 11 medium priority VECs, along with more than 60 activities/stressors, in an effort to prioritize the VECs for action. Work began in 2007 and the assessment was completed in the fall of 2009. The methodology was developed iteratively throughout the process and required frequent modifications as experience was gained in application. Based on this assessment process, it was concluded that even though the number of VECs and activities/stressors reviewed was a subset of VECs identified by DFO Science, the process was extremely difficult to manage.

Based on her experience, Ms. Park notes that the ideal method should provide clear enough guidance that any assessor presented with the same data would arrive at the same score. However, in practice developing guidance that provides this kind of clarity is very challenging when dealing with such a broad range of VECs and stressors. For example, guidance must

cover cases where stressors occur chronically, but are not restricted to a specific area; continuous stressors; chronic stressors that occur annually, but intermittently; and chronic stressors that are unlikely to occur annually.

Following her description of the Newfoundland experience, Ms. Park offered some general comments on the proposed ERAF. The scoring tables are a core feature of the method, and are quite valuable. The use of standardized scoring tables and pathways of effects (POE) models should enhance the speed, consistency and transparency of the assessments. However, as assessments are conducted situations will arise where the tables fail to provide adequate guidance and will need to be further developed to taken into account new conditions. Despite the utility of POEs, Ms. Park expressed some concern about the dependence on POEs in the proposed method, and recommended including a statement in the advisory report to ensure that assessments are not stalled in the event that relevant POEs are not available.

Ms. Park then discussed the scoping phase of the ERAF that identifies VECs. In her written review, which was submitted prior to the RPR Meeting, she noted that the method failed to provide clear guidance and screening criteria for scoping habitats and community/ecosystem properties (see Appendix D). The authors were able to address this issue prior to the RPR meeting and provided some guidance. Table 3, which describes species, is quite good. With some modifications criteria in Table 3 could be used to screen habitats as well as community/ecosystem properties. Ms. Park suggested that it may not be necessary to separate species, habitats and communities as there is a overlap between these components and removing this step would simplify the method. Other relevant criteria could also be incorporated into the screening criteria tables, including ecosystem role criteria developed to score ecosystem sensitivity for individual VECs. Ms. Park recommended simplifying the method of selecting VECs, and to include stakeholders in the beginning. It was noted that the authors' presentation indicated that stakeholder review would be part of the policy review.

The Level 1 risk assessment provides a rapid way to produce preliminary results, thus allowing a greater amount of time for the more labour intensive Level 2 assessments. Level 1 allows users of the ERAF to set priorities before going into the details of Level 2, and is therefore a highly valuable component of the proposed ERAF. It allows Level 2 to focus on analysis on the highest ranked stressors and VECs, which is of particular importance in large areas such as LOMAs where there are many VECs and stressors to consider. Comparing the Level 1 and Level 2 results (scores) is a useful check of the methodology (these scores should be quite similar for the same VECs) and can help to expose sources of error and identify areas where the method can be improved.

Ms. Park noted that users of the ERAF must be aware of the "nibbling effect". To be credible, a method must ensure that significant effects are not ignored because they come from many different low-impact stressors. For example, if a stressor is divided out into enough small activities, the argument can be made that none of the activities are significant, even if the cumulative effects are obvious. It is important to devise a method that prevents the screening out of stressors that are low risk individually, but may have significant cumulative effects, for example, by moving extreme cumulative scores from Level 1 into the Level 2 analysis even if the individual risk scores that comprise the high cumulative score are low. If the approach is to pair activities/stressors, then significant stressors that are associated with numerous activities should be addressed. For example, if the same stressor occurs many times in association with different activities, then consider assessing it as a single stressor. Alternately, broad activity categories that capture all significant sources of a stressor could be used.

Ms. Park then discussed the use of uncertainty in the ERAF. The level of scientific uncertainty is recorded within both Level 1 and Level 2 assessments. High uncertainty in Level 1 can be

used to justify a Level 2 assessment even if risk scores are low. Ms. Park thought this was an appropriate use of the uncertainty scores as long as common sense prevails and it is not used to inflate the importance of a suite of minor stressors that have not been well studied and there is no indication that they cause significant harm. Uncertainty should be considered separately to allow the ready identification of subjects in urgent need of further research, i.e., those areas where action by DFO (research, etc.) could reduce the uncertainty, and provide a sense of the reliability of the results.

Ms. Park had several comments with regards to the Level 2 assessment in the ERAF. First, she stressed that semi-quantitative analysis is not equal to a blend of quantitative and qualitative analysis. For any relative analysis or ranking, it is vital that all components are treated equally. Problems arise when highly detailed quantitative analyses are mixed with qualitative analysis and are called semi-quantitative. Secondly, Ms. Park cautioned against inadvertently including redundancy in the calculations. Redundancy occurs when a detailed spatial analysis is use to score one of the factors (for example, percent area overlap) when in reality it is capturing several other factors as well. This redundancy can lead to under-scoring data-rich stressor-VEC interactions relative to the scoring of data-poor interactions. Ms. Park observed that there is a risk of redundancy in the exposure factors in the risk calculation, and practitioners must be careful not to use the same data twice. For example, fishing effort can encompass both season length and the number and/or density of vessels or gear sets. Ms. Park also noted that it would be helpful to provide context for the intensity of an activity, and suggested that a global maximum could be used. She also noted that it is important to have transparency in how intensity is calculated so that stakeholders can evaluate the validity of the results.

Ms. Park had several comments and recommendations for the calculations used in the proposed ERAF. The math used in Level 2 of the current ERAF is similar to the calculations used in Newfoundland. She noted that the difference in scaling of exposure (scale of 1-10) and consequence (1-3) gives more weight to exposure than consequence. Though she did not consider this a fatal flaw, she did suggest alternative calculations that could help remedy the situation. She suggested that the *Pexposure* term in the risk calculation be scored using a scoring table which considers all three factors (percent area overlap, percent depth overlap, and percent temporal overlap), but only selects a single score, similar to the way that the *Exposure* term is scored in Table 6 or the *Recovery* term is scored using Tables 11-13. These changes would allow the *Exposure* and *Consequence* terms to have equal weight in the risk calculation. Alternatively, the same scale (e.g., 1-10) could be used for both terms. These options would also reduce problems with redundancy in the exposure terms. Ms. Park also thought that the calculations for *ERisk* were valid and useful.

Finally, with regards to the Level 3 assessment, Ms. Park recommended that the authors clarify the purpose of a Level 3 assessment, as there is no point in conducting a third ranking exercise. If the Level 3 assessment is not a relative analysis, the individual assessment can be as detailed as the available data allow. Ms. Park suggested that the proposed ERAF could be simplified by using the Level 1 analysis to rank the VEC/stressor interactions, and merging Levels 2 and 3.

There were no additional questions or discussion following Ms. Park's presentation.

Jameal Samhouri

This section provides an overview of discussion regarding the written review provided by Dr. Jameal Samhouri prior to the meeting (Appendix D) and documents all decisions and agreements to amend the working paper based on this discussion.

Dr. Samhouri provided a presentation on the key points from his review. First, he highlighted what the ERAF can and cannot do. The ERAF can identify the greatest threats to VECs, and determine VECs at greatest risk. It is also scalable, adaptable, and is flexible in the data it can use. It cannot provide a probabilistic assessment of absolute risk, assess societal benefits associated with assuming ecosystem risks, nor can it suggest the most appropriate management response to those risks.

Dr. Samhouri's second point related to cumulative risk. Interactions between different activities/stressors are very important, yet remain poorly studied and poorly understood. Consideration of the disaggregated risk scores can be just as important as the cumulative risk assessment, as management actions often address individual activities/stressors. Dr. Samhouri noted that care must be taken when embedding cumulative risk in ecosystem risk calculations, and also cautioned users of the ERAF to be aware of non-commensurate risk scores across different activities.

The third section of the presentation addressed how uncertainty is dealt with in the ERAF. In the Level 1 and 2 assessments there are places to incorporate uncertainty. However, where possible, it may be better to have a measure of uncertainty associated with each piece of the Level 1 and 2 risk assessment. For example, in some situations knowing the individual uncertainty associated with the *QExposure* and *QConsequence* terms may be valuable to managers. Dr. Samhouri emphasized the importance of being explicit about uncertainty, and knowing the source of that uncertainty. He suggested that many scores will be uncertain due to limited information, resulting in a more VECs than expected moving into the Level 2 analysis. The high number of VECs at Level 2 may create a heavy work load, so the criteria for moving from Level 1 to Level 2 analysis may need to be re-evaluated and modified.

In the next part of his review, Dr. Samhouri provided feedback on the selection of VECs and the use of POE models. He suggested adding an additional step following the VEC screening step to ensure that societal preferences are adequately represented in the final set of VECs selected for the risk assessment. He also suggested the addition of a table that gives a short justification or citation for each selected VEC. Dr. Samhouri liked the use of POE models, and noted their similarity to DPSIR (Drivers, Pressure, State, Impact, Response) models. He wanted to know if POE models could also be developed for natural stressors, and if they could incorporate both indirect effects and interactions between VECs. For example, if a species is impacted by an activity, the predators of that species will be indirectly impacted as well.

The fifth section of the presentation dealt with the risk calculations in the ERAF. The weighting of the exposure and consequence terms can have a substantial influence on the risk calculation. Similarly, risk scores may be disproportionally sensitive to individual criteria due to the number of criteria used to calculate these scores. Dr. Samhouri wanted more discussion on the weighting of exposure and consequence in the calculations and more consideration given to the sensitivity of risk scores to the factors used to calculate them. He also discussed the implications of using a product/multiplicative method of calculating risk (as is done in the proposed ERAF) versus using Euclidean distance calculations. When exposure and consequence terms are very similar, the multiplicative approach is more conservative. Conversely, when there is a greater difference between the exposure and consequence scores, the Euclidean distance approach will be more conservative. The implications of these differences are important to consider and acknowledge.

To conclude his presentation, Dr. Samhouri provided some general comments on the paper. He recommended working through a few examples of Level 1 and 2 risk assessments for a couple of VECs to demonstrate how it is done, and to identify any issues with the method. He also recommended making the scoring tables less subject to interpretation to ensure

consistency and transparency. Finally, he advised providing more direction on how to move from a Level 2 assessment to a Level 3 assessment.

Following Dr. Samhouri's presentation there were several questions regarding how managers will use the results of the risk assessments and how the results will influence investment in strategic operations. From a PNCIMA perspective, the results will be used to inform the development an integrated management plan. The ranking of relative risk of various stressors allows managers to set priorities, and to provide a rationale for subsequent decisions. DFO Oceans also noted that they are relying on the ERAF to provide guidance on how to move forward with setting objectives for MPAs in the Pacific Region. The ERAF will also feed in to deliverables under Canada's *Oceans Act* and *Health of the Oceans* initiative, and will help determine future funding. Results from the PNCIMA-level risk assessments will ultimately feed into the MPA network process. A follow-up question asked how management would decide to shape risk assessments that are done in the future. The nature of requests and final products would vary depending on the context of the issue. Advice may be requested as a paper, or through other means.

There was a brief discussion about the value of developing an effective method to utilize knowledge other people have acquired from doing similar risk assessments to help the process move faster, such as establishing a data library. It was noted that data sharing is useful in the first stage of the ERAF, but would be more difficult and less applicable once you begin working on Levels 2 and 3 assessments as the data required is more detailed and area-specific.

Phil Levin

This section provides an overview of discussion regarding the written review provided by Phil Levin prior to the meeting (Appendix D) and documents all decisions/agreements to amend the working paper based on this discussion. Dr. Levin's review was read by the Chair, John Holmes.

Overall, Dr. Levin found the proposed ERAF to be an advance over the work done in the US and in Australia. He noted it was difficult to fully evaluate the ERAF in the absence of a detailed worked example, though does not hesitate to recommend its use. He also noted that future practitioners will likely be able to improve the ERAF as experience is gained.

Dr. Levin had several recommendations for areas in the paper that would benefit from a greater explanation. He thought that there should be more discussion on the context for the work, and how it fits into the larger ecosystem-based management system. A definition is also required for the term "unacceptable risk". Unacceptable risk is key to the implementation of this ERAF, so there is a need for a clear explanation of how reference levels and benchmarks will be established. Additionally, Dr. Levin felt that there needed to be a much more detailed and technical explanation of the methods. He liked the explanation of why a multiplicative approach was used rather than Euclidean distance, but thought other areas, such as consideration of the consequences of certain choices in the risk calculations, would be beneficial. Lastly, a discussion of data sources and limitations would be useful.

The review made note of the lack of human dimensions in the ERAF. The ERAF focuses on ecological risks, but ignores risks to social, cultural, and economic values. Dr. Levin believes that including the human components of the system is essential when developing an ecosystem-based approach to management. He urged the authors to expand their work to include a human dimension in the current ERAF.

Similarly, Dr. Levin was surprised by the limited role stakeholders play in the VEC identification process. He liked the concept of VECs, and thought the general approach in the ERAF for documenting and identifying VECs was good. However, it was not immediately clear to what extent stakeholders will be brought into the VEC process.

Dr. Levin thought the POE models were a useful approach, but was concerned they would lead to compartmentalization of issues, rather than a more integrated approach. That is, to what extent do POEs interact with each other? Are there examples where more than one activity is built into a single POE? Dr. Levin also felt it would be worth discussing the similarities and lessons learned from other methods that are similar to the POE models used in this ERAF, such as the DPSIR (Driver, Pressure, State, Impact, Response) models, and open standards for conservation. He also suggested considering formal Bayesian Belief Network modeling to conduct Level 1 risk analyses.

There were no additional comments or discussion following Dr. Levin's review.

AUTHOR RESPONSES TO REVIEWERS

This section provides an overview of the authors' responses to issues raised by the reviewers and documents all decisions/agreements to amend the working paper based on this discussion.

APPLICABILITY OF THE ERAF TO MANAGEMENT

Several comments from reviewers expressed concern about the applicability of the ERAF to management, particularly given that there is no explicit consideration of socio-economic interests. The authors explained that the focus on ecological components was in part due to feedback from stakeholders in the PNCIMA process who were uncomfortable with solely using risk to assess valued socio-economic components. It was noted that the ERAF is one of many tools available to managers, and while VECs are ecological, many are considered valuable for socio-economic reasons. The clients (Ecosystem Management Branch) agreed with this judgement and pointed out that in the case of MPAs the focus is on ecological rather than socio-economic components. However, stakeholder consultation is still an integral part of integrated oceans management and occurs throughout the process. The importance of socio-economic factors was acknowledged, but will be addressed through other processes.

A related question was raised as to the role of traditional ecological knowledge (TEK) in the ERAF and it was indicated that TEK is critical to the identification of some VECs and in creating a list of VECs that has stakeholder approval. It was noted that the process for where and when to involve stakeholders, including First Nations, is still being worked out.

There was agreement that the Research Document and the SAR needed to provide an overview of how the ERAF fits into the overall integrated management process. It was also agreed that there needed to be an explicit acknowledgement of the importance of socio-economic factors and stakeholder involvement, but that those aspects were beyond the scope of the current document, and would be dealt with through other processes.

HIERARCHICAL NATURE OF THE ERAF

Some concern was raised in the reviews about how VECs move through the various levels of the ERAF. The authors clarified that not every process needs to go through all three levels of the ERAF. The ERAF can be tailored to meet context-specific needs. For example, a small MPA may decide to omit Level 1 and go directly to Level 2 to get a more detailed analysis. It was agreed that language regarding the context-specific nature of different uses should be added to the Research Document. It was also agreed that modular was a better descriptor than

hierarchical for the application of the ERAF because each of the risk assessment levels can be applied independently without moving through them in order, as implied by a hierarchical ERAF.

INCORPORATION OF INDIRECT EFFECTS IN POE MODELS

Reviewers questioned whether or not POE models could incorporate indirect effects. The authors replied that indirect effects can be incorporated, but noted that the methods to do so are not fully described in the working paper. They acknowledged that the various interactions between VECs hadn't been wholly captured in the working paper.

It was pointed out that there are two ways of approaching POEs: basing them on the activity, as is done in the working paper, or basing them on the VEC. A POE model based on the activity traces impacts from the activity to the things impacted by the activity and is consistent with the approach used in environmental impact assessments. In contrast, POE models based on VECs trace all of the activities that affect a VEC back to the VEC. Use of either approach should produce the same results, but the articulation of these results is quite different. It was noted that when breaking stressors down by activity it can be difficult to articulate VEC interactions. Identifying interactions between VECs is a necessary next step and will be challenging. Determining ways to do this will probably depend on the VEC and spatial scale.

RISK

The authors noted that there are many ways of rolling up the information in the ERAF. For example, the highest ranking stressors could be identified, a set of VECs at highest risk can be singled out, or a list of relative risks to VECs compiled. The intended final use of the information from the ERAF will determine which method is most appropriate. It was agreed that an explicit statement should be added to the Research Document regarding ways in which the results of the ERAF can be presented.

There was discussion regarding the use of relative rather than absolute risk in the proposed ERAF. The authors stated that it was extremely difficult to capture absolute risk in an area the size of PNCIMA. However, a Level 3 risk assessments would provide a measure of absolute risk, and would also help provide thresholds to facilitate management decisions. The ERAF did not develop the methodology for a Level 3 assessment, though it does provide the context for such assessments, and provides guidance in identifying VECs that are at higher risk and may be worth exploring further with a Level 3 assessment. It was noted that a Level 3 assessment may not be possible in some situations due to a lack of available data. In these circumstances, the ERAF is able to provide a mechanism for moving forward with management decisions through the use of the Level 1 and 2 risk assessments. It was agreed that the Research Document needs to clarify that the Level 1 and 2 assessments provide an estimation of relative risk rather than absolute risk, and that some discussion concerning the use of relative risk rather than absolute risk also should be added to the Research Document..

It was noted that the Groundfish Section at PBS developed a risk assessment ERAF that includes a step allowing users to examine the mitigation measures currently in place. This step enables users to decide whether or not identified risks have been adequately dealt with through existing management measures (e.g., quota, total allowable catch, restricted season), or whether further risk assessment and recommendations for mitigation are required. The authors agreed to add some discussion on the role of existing mitigation measures on risk assessment to the Research Document.

UNCERTAINTY

The reviewers of the working paper had some concerns regarding the way uncertainty was used in the ERAF, specifically, whether it was being used to weight risk scores. The authors clarified that uncertainty did not affect scoring, but instead was intended to be used to provide additional

information to management. They noted that scoring uncertainty was a way to flag VECs or issues that may need additional information, and can therefore be a used as a strategy to increase knowledge/get more information.

There was discussion around that fact that there were likely to be a large number of uncertain components involved in the different levels of the risk assessment, which is likely to pose some challenges as the ERAF is implemented. It is challenging to decide whether to include uncertainty in the risk assessment or to record it separately when working with qualitative assessments. The different approaches can lead to differences with respect to risk averse/risk tolerance management strategies. It was noted that the ERAF was developed to provide information to decision-makers and that presenting uncertainty separately may facilitate prioritizing VECs. It was pointed out that reporting uncertainty separately is consistent with the CSAS process of recording uncertainty. Fuzzy logic was also put forth as a possible way of incorporating uncertainty into the risk scores.

OTHER ISSUES

Other issues that were brought up during the authors' response to the reviewers were highlighted as needing further discussion later in the meeting. There was discussion around the way in which activities and stressors are framed, and whether activities that cause similar stressors should be lumped together or whether stressors should be split apart into their component activities and dealt with separately. It was also noted that it can be hard to distinguish between activities and stressors. The comment was made that users of the ERAF could use the International Union for the Conservation of Nature's (IUCN) internationally accepted topology for activities to distinguish between activities and the categories in which they fall. There was some discussion on the need for guidance on how to deal with issues like continuous pressures.

GENERAL DISCUSSION

SCORING (MATH)

There was extensive discussion regarding the mathematics in the ERAF. Discussion focused on the use of the multiplicative versus Euclidean distance approaches to calculating risk, how exposure and consequence should be weighted (i.e., the scales and sub-terms used to assess each term), and the sensitivity of the calculated risk score to the exposure and consequence axes.

Multiplicative Approach versus Euclidean Distance

The authors chose to utilize the multiplicative approach to calculate risk in the proposed ERAF rather than Euclidean distance. They provided an overview of both approaches, and it was noted that the relative rankings resulting from the two systems are often similar. However, there are a couple of important differences. First, if the difference between the exposure and consequence scores is large, then the Euclidian approach produces a more conservative ranking of risk than the multiplicative approach. Conversely, when the difference between the exposure and consequence scores is small, the multiplicative approach produces more conservative rankings than the Euclidean distance approach. A second key difference lies in how the two methods rank medium risk. A study by NOAA and The Natural Capital Project found that rank correlations between the two approaches were very high, with the exception of middle range scores. As the ERAF is designed to rank stressor/VECs, those differences may be important from a management perspective. Euclidean distance also provides a more intuitive visual output: the further away from the origin, the greater the risk. It was recommended that the Research Document include an example in which Euclidean distance is

applied. It was agreed that the multiplicative approach was suitable, but the first few case studies to use the ERAF should conduct their analysis using both the multiplicative approach and the Euclidean distance approach. These case studies would provide a comparison of results from each approach in order to both calibrate the method and to note any significant differences in rankings. Some concerns were raised that these case studies would substantially increase the workload depending on the number of VECs and stressors under consideration.

Weighting Exposure and Consequence and the Sensitivity of the Axes

Exposure is ranked on a scale of 1 to10 in the proposed ERAF, while consequence is ranked on a scale of 1 to 3. The authors were asked why exposure had been given higher weight than consequence when consequence is the component that identifies long-term harm. The authors replied that a limited scale was used for consequence because it is harder to calculate, and, generally, less is known about the sub-components in the consequence term. For example, there are a range of attributes that affect recovery, a factor in the consequence calculations. These recovery attributes can be hard to capture and quantify. Concern was expressed that if the consequence term has lower weighting, then the risk profile of catastrophic events may be under estimated. There was agreement that the exposure and consequence scores should be normalized on the same scale. There was discussion regarding how the scores should be normalized, keeping in mind that the wider the scale the broader the spread of risk. Scales of 1 to 5 and quartiles were suggested as possibilities, though a single method was not recommended. Regardless of the scale that is chosen, it was recommended that the scale should be based on whole numbers and that 0 should be avoided.

There was discussion amongst participants regarding the number of subcomponents comprising the exposure and consequence axes and the relative sensitivity of these axes to the subcomponents. There was concern that exposure and consequence were not defined with an equal number of subcomponents because from a precautionary perspective, both terms are of equal importance to risk. It was agreed that there should be clearer documentation of the assumptions behind the subcomponents, and why they were selected and that some balancing of the subcomponents might be needed. For example, both areal and depth factors in the exposure term appear to overlap. There was a brief discussion of temporal overlap and scoring, particularly temporal overlap of a VEC with respect to life history period of the VEC. This overlap is captured in the consequence term but not very well. It was recommended that life history period overlap should be captured in the exposure term or alternatively, that VECs should be defined to specifically capture important life history periods, e.g., a VEC could be spawning aggregations of species X.

There was a question about why acute and chronic factors in the consequence score were added before being multiplied. The authors explained that they added the scores for these terms first because it better represented the character of the problem. In this situation there is an interest in the risk of both acute and chronic factors. If one is particularly severe while the other is milder, taking the average of the two would dilute the impact of the more severe factor. There is a desire to capture the risk of both, rather than the average since this approach more clearly articulates to managers the main driver of the risk score.

The authors were asked if the probability of exposure or consequence was incorporated into the current method. They responded that probability was incorporated into some of the subcomponents of exposure and consequence, for example, temporal and areal probability of exposure, and catchability.

UNCERTAINTY

There was discussion surrounding uncertainty and how it was used. There was some concern about how uncertainty was rolled up and that it was not done in the same way as overall risk. It

was suggested that a relationship between the level of uncertainty and the sources of data could be established. The authors stated that they did not weight uncertainty based on data sources because it made the ERAF less user-friendly and made the results less clear. It was decided that the authors should relate uncertainty to data quality. It was suggested that uncertainty scores could be re-binned as 1 to 5 instead low to high thereby making it comparable to the risk scores. If the 1 to 5 scale is used, then there should also be 5 questions related to uncertainty. It was agreed that results of the ERAF should provide an explanation for the uncertainty score, highlighting the drivers of that score, e.g., lack of data, lack of knowledge.

OUTPUTS – LOOK & FEEL

The proposed ERAF categorized risk scores into five bins, ranging from negligible to extreme, each with proposed actions to address the risk. There was discussion on whether these categories were appropriate since they seem to reflect value judgements and the associated actions were considered more prescriptive than necessary. It was agreed that the revised Research Document would not categorize risk, rather an explanation of the risk score and its meaning would be provided, describing the primarily drivers of that score, i.e., subcomponents of exposure or consequence, uncertainty. It was agreed that the outputs of the ERAF should include a table with risk scores, an explanation that justifies the score and drills down to the subcomponent level as well as the uncertainty score and justification for that score. A graphical output of risk with exposure and consequence axes should also be produced.

ERAF APPLICABILITY

There was much discussion around the lack of socio-economic considerations in the working paper and the role of human dimensions in the selection of VECs. It was emphasized that this ERAF is only looking at biological components of ecosystems, and is not evaluating socio-economic considerations. The socio-economic analysis will take place in a parallel process. However, it was acknowledged that some VECs, such as healthy fish stocks, will indirectly capture some human values. There was agreement that there should be clear language in the SAR noting that outputs from the ERAF should be considered in conjunction with valued socio-economic components and other human dimensions. This discussion highlighted the need to be explicit about the scope of the ERAF, as well as what it can and cannot do.

There was concern that none of the VEC/stressor interactions would be screened out by the Level 1 risk assessment because it considers cumulative effects, which resulted in discussion as to whether or not there should be language in the Research Document or SAR that provides advice on how many VEC/stressor interactions can be moved to Level 2. It was suggested that the advice should not be overly prescriptive, but that it provide some guidance and describe the implications of moving to the next assessment level. For example, moving from a Level 1 to a Level 2 assessment may require more research and time, and management actions may be required. It was recommended that the decision about what to move to Level 2 be left to managers who will have to weigh the various costs and benefits of further analysis.

There was discussion regarding whether or not existing mitigation measures should be considered in the ERAF. It was suggested that mitigation measures could be considered to eliminate the need to conduct a risk assessment on particular VEC/stressor interactions. There was some concern that if risk assessment is not conducted because some mitigation measures are in place, then cumulative effects that may be relevant could be missed. It was noted that although there is not an explicit mitigation component in the ERAF, that some mitigation measures are taken into account in the exposure score. The ERAF assumes that existing mitigation measures for a VEC (e.g., fishery quota, total allowable catch or TAC) remain in place unchanged and evaluates risk to the VEC on this basis. If the mitigation measure is changed (e.g., increased quota or TAC), then the risk profile of the VEC should be re-evaluated. It was

decided that the decision about whether or not to explicitly include mitigation measures should wait until a few case studies have been done.

Participants wanted to ensure that the ERAF can be utilized by parties external to DFO. In order to be applicable in other situations, the ERAF must be flexible, replicable, and useable. As the ERAF is applied the lessons learned should be documented and made available. It was also noted that clear and consistent guidance on scoring was needed to assure usability and replicability among different users.

PATHWAYS OF EFFECTS (POE) MODELS

There is a national guidance document on POE models and how to build them. The document recommends having POE models peer-reviewed, either in a workshop setting in which models are developed and reviewed simultaneously, or after the model has been completed. Currently, about six POE models have gone through a CSAS process and the intent is to build a national library of peer-reviewed POE models. Participants supported the use of POE models, as they are visual, transparent, make assumptions explicit, and are very helpful. It was recommended that efforts be made to collaborate and share POE models with other researchers, both internally and externally.

There were a couple of concerns raised regarding POE models. There was concern that the proposed ERAF relied too heavily on the use of POEs and would be stalled if an appropriate POE model was not available. It was agreed that in the absence of POEs the process should not be stalled and that as a result the working paper should provide guidance on how to move forward without a POE. It was noted that the paper should include other options such as DPSIR and Bayesian Belief Networks that could be applied in the absence of appropriate POE models. There was additional discussion around whether or not POE models could capture indirect effects. The authors walked through an existing generic POE model and showed how indirect effects are captured in these models. Visually, indirect effects are captured by dotted red lines in the POE whereas direct effects are shown as solid black lines.

SELECTION OF VECS

The authors asked for feedback on the table used to develop a set of components and subcomponents used to structure the ecosystem (Table 2) and the tables (Tables 3 and 4) and section (Section 2.1.1.2) used to help identify and classify VECs for species, habitat, and community/ecosystem components. There was discussion as to whether or not the screening criteria were too broad, resulting in the screening out of few VECs, and whether the proposed ERAF was too species-centric. These questions led to discussion regarding whether or not the ERAF should be flexible enough to address a variety of applications, or whether it should provide specific guidance on how to screen out VECs. It was acknowledged that the reasons for selecting VECs for analysis will vary depending on the issues and questions being asked, and the specific conservation objectives of the project. Therefore it would be beneficial to have flexibility within the ERAF to address different needs. There was also discussion around the need to be realistic about how many VECs can be feasibly analyzed through the ERAF. One participant with experience in similar analysis recommended 10 as a reasonable number. There was agreement that the guidance and criteria in the working paper provided should be kept, and it should be emphasized that VECs include habitats and community/ecosystem properties, not just species. It was agreed that the Research Document should state that the screening criteria are not absolute and that other habitat classification systems are available (e.g., Ecologically and Biologically Significant Areas, Vulnerable Marine Ecosystems, Open Standards, Puget Sound Nearshore Partnership, the Australia ERAEF) that could be used to screen VECs. The Research Document should note that the specific screening criteria used will depend on the goals and objectives of the analysis. It was also recommended that the authors ensure that the screening criteria are consistent with the criteria listed in Table 13 and the metrics in Appendix

B of the working paper. For example, structure/function and ecosystem services criteria should be added. It was recommended that the SAR include wording on how to interpret the results of the ERAF in terms of community/ecosystem structure and function. Lastly, it was suggested that the term Criteria should be replaced by Considerations as it provides more latitude with respect to the choice of properties to use in response to specific questions.

LESSONS FROM OTHER RISK FRAMEWORK APPLICATIONS

Participants in the meeting who were familiar with similar applications of risk assessment frameworks offered some advice regarding the application of the proposed ERAF. They emphasized that conducting this sort of assessment is very labour intensive and costly and they recommended limiting the assessment to 8 -10 VECs. It was also noted that resources will be needed to facilitate the development of POE models. It was recommended that the ERAF be constructed so that users can investigate the sensitivity of the risk profile and determine what factors have high leverage on risk and which factors do not influence risk significantly. Similarly, it was recommended that allowing users to be innovative with output from the ERAF is beneficial, i.e., do not place restrictions on how the outputs can/should be used. A comment was made suggesting that it would be valuable at some point to develop computer software that will facilitate these sorts of assessments and make sensitivity analysis easier. It was noted that there are currently similar software programs available, such as InVEST.

CONCLUSIONS

- The ecological risk assessment framework (ERAF) supports the identification of meaningful ecological priorities as a guide for the development of objectives, strategies and actions in PNCIMA and MPA initiatives and it is a necessary component for the implementation of DFO's ecosystem-based integrated Oceans management in Pacific Region.
- The ERAF is endorsed as suitable for identifying and prioritizing the activities and associated stressors that have the potential to affect valued ecosystem components (VECs) in support of ecosystem-based Oceans management in the PNCIMA and Pacific Region MPAs.
- Use of the ERAF is expected to facilitate the communication of clear and transparent science advice to managers on the risk of ecological consequences of anthropogenic stressors on ecosystem components, and identify stressors that may require attention.
- The ERAF identifies VECs at risk and the degree and source of risk to those VECs, but it does not identify the most appropriate management responses to these risk(s) and it is not intended to provide a probabilistic assessment of absolute risk nor does it include an assessment of societal benefits associated with assuming ecosystem risks.
- It is recommended that outputs from the initial application of the ERAF to PNCIMA or MPAs in Pacific Region be reviewed by a future CSAP process to address the performance of the ERAF. Issues of transparency, consistency, compatibility, and repeatability are of importance for this performance review.
- The ERAF is intended to address biological Valued Ecosystem Components (VECs), although non-biological criteria (e.g., social, economic) could be used to define VECs, depending on the questions asked by managers. However, this flexibility in defining VECs may have operational impacts in applying the ERAF since, for example, the choice of criteria used for habitat/community screening prior to a Level 1 risk assessment may be dependent on the choice of VECs.

- POE models are an appropriate method for identifying mechanistic linkages between human activities and stressors impacting VECs. However, there are other, equally valid alternative approaches that could have been chosen for the ERAF and could be used to identify these linkages if no POE model for a particular activity/stressor combination is available.
- The ERAF uses a modular risk assessment methodology to determine single and cumulative risk of harm to VECs, and ultimately, rank stressors/VECs based on single and cumulative risks. It also assesses the relative risk to ecosystem properties and provides methods for explicitly capturing and reporting uncertainties in data quality, which may guide management strategies and actions. The risk assessment methodology has three levels of risk assessment. Movement of VECs through the different levels of risk assessment is context-specific and as a result not every process will go through all three levels. This risk assessment methodology is appropriate, considering the flexible design of the ERAF, although some modifications may be needed for the scoring of risk at different stages and the additivity assumption for cumulative risk.
- Multiple sources of information ranging from peer-reviewed to expert opinion can be use simultaneously in the ERAF as it is intended to assess relative rather than absolute risk to VECs and uncertainties related to information are captured for interpretation of risk scores The ERAF can also be used to screen risks posed by potential future human activities. The ERAF can be applied iteratively as new information/interpretations become available.
- The ERAF explicitly considers uncertainty in communicating risk scores at different stages since clear documentation of uncertainty informs interpretation of these scores. It is recommended that the results of Level 1 and Level 2 assessments incorporate risk scores and explicit justification for the score, including identification of the term (exposure or consequence) and specific sub-term(s) driving these scores as this information may inform management strategies and actions.
- Development of the ERAF was guided by best practices and recommendations from risk assessment processes in other countries and ERAFs developed within DFO for other purposes. It is recommended that the ERAF be considered as an example of a Pacific Region Science approach to assessing VEC risk profiles to inform a future national process on developing objectives, strategies, and actions as DFO implements ecosystem-based integrated oceans management.

RECOMMENDATIONS AND ADVICE

This section summarizes the recommendations and advice that were agreed upon by the participants at the Regional Peer Review meeting.

GENERAL ADVICE

- The ERAF and guidance provided should be revisited and modified as needed once experience has been gained in its application;
- Modifications to operational components and decision rules concerning scoring should be well documented ("lessons learned") as the ERAF is implemented;
- Clear and standardized scoring advice for the risk assessment components should be developed to ensure that results can be replicated between different users;
- Developing a library of POEs and a common database of life history characteristics, activities/stressors would be valuable in facilitating future use of the ERAF; and,
- Comparing Level 1 and 2 risk scores would provide a useful check for internal consistency in scoring risk, as these scores should be similar for VECs elevated to a Level 2 assessment.

GUIDANCE IN THE SAR

- Provide an overview of how the ERAF fits into the overall integrated management process;
- Provide an explicit statement about the scope of the ERAF, the assumptions it makes, and what it can and cannot do;
- Provide explicit acknowledgement of the importance of socio-economic factors and stakeholder involvement. Note that these aspects are beyond the scope of the current document, and will be dealt with through other processes;
- The levels of the ERAF do not need to be completed sequentially: Levels can be omitted if desired. The decision regarding which VEC/stressor combinations should move to Level 2 is at the discretion of managers, who must weigh the various costs and benefits of further analysis;
- Provide reference to other available classification systems (e.g., BCMEC, BCMCA, EBSAs, VMEs, habitat classification systems) that can help guide VEC selection. The purpose of the ERAF will influence how you screen VECs to be considered in the ERAF.
- Note that VECs include habitats and community/ecosystem properties, not just species.
- The number of VECs considered in any iteration of the ERAF should be limited to what is realistically feasible (perhaps 8 to 10);
- POE models are appropriate for use in the ERAF as they are visual, transparent, make assumptions explicit, and are very helpful. When possible, peer reviewed POEs should be used. In the absence of POEs, other methods (e.g., Bayesian belief networks, DIPSR models, best available information) can be used;
- The multiplicative approach is suitable for calculating risk in this ERAF. However, there are other alternatives, such as Euclidean distance. The first applications of this ERAF should calculate risk using both the multiplicative and the Euclidean distance approach. These case studies would provide a comparison of results from each approach in order to both calibrate the method and to see if any significant differences are noted;

- Consider irreversible consequences;
- Outputs of the ERAF should include tables with risk scores, justifications for those scores, the contribution of each subcomponents to the score, uncertainty scores, the rational for the uncertainty scores, and a graphical output of risk with exposure and consequence axes;
- Provide guidance on how to interpret the results of the ERAF in terms of community/ecosystem structure and function;
- As the ERAF is applied the lessons learned should be documented and made available so that other users, both internal and external to DFO, can apply the ERAF; and
- Future reviews of the ERAF should consider whether or not to explicitly include mitigation measures in the ERAF.

RECOMMENDATIONS FOR REVISIONS IN THE RESEARCH DOCUMENT

Application

- Provide an explicit statement about the scope of the ERAF, the assumptions it makes, and what it can and cannot do;
- Provide explicit acknowledgement of the importance of socio-economic factors and stakeholder involvement. Note that these aspects are beyond the scope of the current document, and will be dealt with through other processes;

Hierarchy

- Explain that the use and application of the ERAF and will depend on the purpose of the risk assessment, e.g., whether it is for an MPA or LOMA or some other purpose;
- Highlight that the ERAF can be considered modular rather than hierarchical: levels do not need to be conducted sequentially if there is no need for lower levels of the assessment;

Selection of VECs

- Ensure that the screening criteria are consistent with the criteria listed in Table 13 and the metrics in the appendix;
- Clarify that the provided criteria are only potential criteria. The specific screening criteria used will depend on the goals and objectives of the analysis;
- Provide reference to other available classification systems (e.g., BCMEC, BCMCA, EBSAs, VMEs, habitat classification systems) that can help guide VEC selection. The purpose of the ERAF will influence how you screen VECs to be considered in the ERAF;
- Note that VECs include habitats and community/ecosystem properties, not just species. Structure, function and ecosystem services should be considered when selecting VECs;
- Note that the number of VECs considered in any iteration of the ERAF should be limited to what is realistically feasible (perhaps 8 to 10);
- Emphasize that VEC selection must be transparent and well documented (e.g., why they are valued, and who they are valued by);
- Emphasize that care must be taken when defining VECs (i.e., lumping versus splitting);

POE Models

- State that peer reviewed POEs should be used when possible. In the absence of POEs, other methods (e.g., Bayesian belief networks, DIPSR models, best available information) can be used;

Equations

- Provide an example of calculating risk with the Euclidean distance approach; Normalize the exposure and consequence so that they are on the same scale. Scales of 1 to 5 and quartiles were suggested as possibilities, though a single method was not recommended;
- Clearly document the assumptions behind the subcomponents of exposure and consequence, and why they were selected;
- Highlight the data limitations and assumptions of assuming cumulative risk is additive;

Uncertainty

- Relate uncertainty to data quality;
- Re-bin uncertainty scores so that they are comparable to the risk scores (e.g., use 1 to 5 for uncertainty if exposure and consequence are scored from 1 to 5);
- Match the number of questions related to uncertainty to the scale of the risk score (e.g., 5 questions for a scale of 1 to 5);

Risk

- Clarify that Levels 1 and 2 provide an estimation of relative risk rather than absolute risk;
- Discuss why relative risk is used instead of instead of absolute risk;
- Discuss the appropriateness of prioritizing analysis in the ERAF given existing mitigation measures;
- Remove the risk category bins (Table 8) and the value in the language describing the different levels of risk (Table 9) and replaced with text that provides context for what the risk scores mean; and
- Explicitly state that there are a number of ways to present the final results of the ERAF. Outputs of the ERAF should include tables with risk scores, justifications for those scores, the contribution of each subcomponents to the score, uncertainty scores, the rational for the uncertainty scores, and a graphical output of risk with exposure and consequence axes.

SUMMARY AND CLOSING

The Chair thanked attendees for their participation in the meeting either in person or via webinar. He noted that the spirit of collaboration fostered during the meeting had led to constructive suggestions that will improve the Research Document and resulting ERAF. There was consensus that the meeting had met its objectives as outlined in the TOR and that the next step, applying the ERAF and reviewing the results in a future CSAP process, was strongly anticipated and critical to the overall success of the ERAF.

The conclusions of this meeting were captured in the associated Science Advisory Report (DFO 2012). One DFO Science Research Document will be produced as a result of this meeting.

ACKNOWLEDGEMENTS

The Chair acknowledges the assistance of Marilyn Joyce and Nic Dedeluk in organizing and running a smooth meeting. The Chair thanks the working paper authors for a well written paper and spirited participation in responding to all questions and comments. He also thanks Laura Park (DFO), Jameal Samhouri (NOAA) and Phil Levin (NOAA) for their detailed and constructive reviews of the working paper that stimulated highly constructive discussion and recommendations. Meeting participants, many of whom are highly experienced risk assessment practitioners are commended for engaging in a highly collaborative dialogue with the authors and Chair that improved all of the products resulting from this meeting. Finally, the Chair and working paper authors are also grateful to Jessica Finney (DFO Science) and Julie-Beth McCarthy (DFO Oceans) for their skill as rapporteurs in capturing the relevant discussion, agreements and recommendations.

APPENDIX A: TERMS OF REFERENCE

Risk-based Assessment Framework to Identify Priorities for Ecosystem-Based Oceans Management in the Pacific Region

Regional Peer Review - Pacific Region

May 8 - 10
Nanaimo, BC

Chairperson: John Holmes

Context

The establishment of the Pacific North Coast Integrated Management Area (PNCIMA) and Pacific region Marine Protected Areas (MPAs) presents a broad range of ecosystem-based challenges and opportunities for Oceans Management. A key step in meeting these challenges and opportunities is the development of a risk-based assessment framework founded on sound science that (i) identifies and prioritizes ecosystem issues within Large Ocean Management Areas (LOMAs) and MPAs, and (ii) informs the development of conservation objectives, management strategies and action plans for these managed areas. Such a framework would apply a systematic, science based and defensible risk based decision making structure to these areas and provide advice and guidance to support the transition from high-level aspirational principles and goals to more tangible and specific objectives, strategies and actions that could be implemented in the Pacific North Coast Integrated Management Area (PNCIMA) and MPA initiatives in Pacific Region.

A team of DFO Oceans and Science staff have collaborated to create a structured approach to assessing the potential risk to ecosystem components from human activities and their associated stressors in these managed areas. The goal of developing this risk-based assessment framework is to provide managers with science advice on ecosystem priorities, together with the processes and tools that can be used in the development of conservation objectives and management measures in PNCIMA and MPA initiatives in Pacific Region. This advice could also be valuable to inform other risk-based approaches applied within the Pacific Region (e.g. DFO Habitat Ecosystem Risk Assessment Framework, DFO's Sustainable Fisheries Framework).

The key elements of the proposed risk-based assessment framework are:

1. identification of the key features or properties of the system (valued ecosystem components or VECs), including species, habitats and community/ecosystem properties;

2. identification of the activities and stressors that have the potential to affect these VECs using pathways of effects models (POE); and,

3. an assessment of the risks of harm to each VEC from each activity and associated stressors using appropriate criteria and scoring methodology.

The risk scores that are calculated from the risk-based assessment framework identify which VECs and/or activities and stressors may require enhanced management attention. By

providing a systematic and transparent process for gathering, evaluating and recording information related to the risk of harm from human activities/stressors on VECs, this risk-based framework may be used as a key information tool to identify priorities for PNCIMA management and MPAs and develop more specific conservation objectives, management strategies and action plans including monitoring, research and management assessments as appropriate.

Objectives

The following working paper will be reviewed to provide the basis for discussion and advice:

An Ecological Risk Assessment Framework (ERAF) for Ecosystem-Based Oceans Management. O, M., R. Martone, L. Hannah, L. Grieg, J. Boutillier and S. Patton. CSAP Working Paper 2012/P46

The overarching objective of this Regional Peer Review Meeting (RPR) is to assess whether the risk-based framework outlined in the working paper serves the intended function of identifying and prioritizing the activities and associated stressors that have the potential to affect valued ecosystem components (VECs), for the purposes of informing the development of conservation objectives, strategies and actions for application in PNCIMA and MPAs.

Specific issues to consider in addressing this objective include:

1. Methodology used to categorize and identify Valued Ecosystem Components (VECs);

2. Pathways of effects (POE) models to elucidate the potential effects of activities and associated stressors to VECs (an example POE will be provided);

3. Risk assessment methodology used to determine risk of harm to VECs (i.e. high, medium, low);

4. Assessment of uncertainty at different stages in the risk assessment;

5. Flexibility of the risk-based assessment framework to allow for application at different management scales (e.g. Environmental Impact Assessments, Habitat) if appropriate;

6. Adaptability of the risk-based framework to allow integration of additional information as it becomes available; and

7. Recommendations on the completeness and appropriateness of the framework for identifying VECs, threats to VECs, risk of harm to VECs and science advice on priorities that are appropriate for the development of conservation objectives.

Expected publications

- CSAS Science Advisory Report (1)
- CSAS Research Document (1)
- CSAS Proceedings

Participation

DFO Science, Habitat, Species at Risk, Fisheries Management
DFO Risk Assessment Center of Expertise
DFO Ecosystem Management
Environment Canada
Parks Canada
First Nations
Universities
Environmental Non-governmental Organizations
Fishing Industry
Province of British Columbia
United States National Oceanic and Atmospheric Administration

Additional Information and References Cited

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Halpern, B.S., K.A. Selkoe, F. Micheli, and C.V. Kappel. 2007. Evaluating and ranking the vulnerability of global marine ecosystems to anthropogenic threats. Conservation Biology. 21: 1301-1315.

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APPENDIX B: AGENDA

Regional Peer Review Meeting (RPR)
Centre for Science Advice Pacific

AGENDA

Risk-based Assessment Framework to Identify Priorities for Ecosystem-Based Oceans Management in the Pacific Region

May 8-10, 2012

Pacific Biological Station
3190 Hammond Bay Road, Nanaimo, BC, V9T 6N7

Chairperson: John Holmes

Tuesday May 8 – Day 1		
09:30	Welcome and Introductions	John Holmes
09:45	Review Agenda and Housekeeping Items	John Holmes
10:00	CSAS Overview and Meeting Procedures	Marilyn Joyce
10:15	Review Terms of Reference/ Context for Framework – intended uses/applications of the tools being reviewed	John Holmes/Neil Davis/Kate Ladell
11:00	Presentation of Working Paper	Miriam O, Rebecca Martone
12:15	***Lunch Break***	
13:15	Reviewer Presentation and Authors Response	Laura Park
13:45	Reviewer Presentation and Authors Response	Jameal Samhouri
14:15	Reviewer Presentation and Authors Response	John Holmes for Phil Levin
14:45	***Break***	
15:00	Group Discussion to Identify Issues and Topics	RPR Participants
16:15	Summary of Issues and Topics for further discussion	RPR Participants
16:30	***Adjournment***	

Wednesday May 9 – Day 2

09:00	Introductions & Housekeeping	John Holmes
09:15	Review Day 1, Terms of Reference, and Agenda for Day 2	John Holmes
09:30	Scoring (Math) Capturing Indirect Effects/Interactions in POEs	RPR Participants
10:30	***Break***	
10:45	Habitat & Community Selection Criteria Community Properties & Linkages to Ecosystem Function Framing Activities/Stressors (Lumping/Splitting)	RPR Participants
12:00	***Lunch Break***	
13:00	Framework Applicability Uncertainty Robustness/Replicability of Framework Outputs – look and feel Mitigation Measures Lessons from other risk framework applications	RPR Participants
14:30	***Break***	
14:45	Identifying VECs Pathways of Effects Models Ecological Risk Assessment Framework Discussion and resolution - Issues & Topics	RPR Participants
16:30	***Adjournment***	

Thursday May 10 – Day 3		
09:00	Introductions & Housekeeping	John Holmes
09:15	Review Days 1 and 2, Terms of Reference, and Agenda for Day 3	John Holmes
09:30	Discussion & resolution of issues from Day 1 & 2	RPR Participants
10:30	***Break***	
10:45	Science Advisory Report (SAR): Develop consensus: • Key findings & conclusions • Uncertainties • Application of framework for PNCIMA and Pacific Region MPAs • Recommendations for future work • Recommendations for Working Paper	RPR Participants
12:000	***Lunch Break***	
13:00	Science Advisory Report (SAR): Develop Consensus Continued	RPR Participants
14:30	***Break***	
14:45	Finalize (Draft) Science Advisory Report	RPR Participants
16:30	***Adjournment***	

APPENDIX C: ATTENDEES

Name	Affiliation
Alidina, Hussein	World Wildlife Fund
Bernhardt, Joey	InVEST/The Natural Capital Project
Biffard, Doug	BC Parks
Bodtker, Karin	Living Oceans Society
Boldt, Jennifer	DFO Science MEAD
Boutillier, Jim	DFO Science MEAD
Brown, Robin	DFO Science OSD
Burt, Jenn	Canadian Parks and Wilderness Society
Cargill, Sally	Province of BC
Chandler, Peter	DFO Science OSD
Cormier, Roland	DFO, OHEB, Moncton
Davis, Neil	DFO OHEB Oceans
Day, Andrew	West Coast Aquatic
Dunham, Jason	DFO Science MEAD
Evanson, Melissa	DFO FAM - Gwaii Haanas/SFF
Finney, Jessica	DFO Science MEAD
Freethy, Diana	DFO OHEB Oceans, Prince Rupert
Giangioppi, Martine	DFO, Oceans, Ottawa
Gillespie, Graham	DFO Science MEAD
Greig, Lorne	Essa Technologies LTD
Hannah, Lucie	DFO OHEB Oceans/Science
Holmes, John	DFO Science MEAD
Holt, Kendra	DFO Science MEAD
Hunter, Karen	DFO Science SAFE
Hyatt, Kim	DFO Science SAFE
Ibey, Hilary	DFO OHEB Oceans, Vancouver
Jones, Greg	Environment Canada, Vancouver
Joyce, Marilyn	DFO Science CSAP
Ladell, Kate	DFO OHEB Oceans
Lemieux, Jeffery	DFO, North Coast, Prince Rupert
Levin, Phillip	NOAA, Seattle
Lougheed, Cecilia	DFO Science, Ottawa
Martone, Rebecca	DFO OHEB Oceans/Science, Vancouver
McCarthy, Julie-Beth	DFO Oceans, Vancouver
McIssac, Jim	T. Buck Suzuki Foundation
Morgan, Ken	Environment Canada-CWS
Mose, Brian	Groundfish Trawl Advisory Committee
Newman, Candace	Natural Resources Canada
Nishimura, Derek	DFO OHEB, Vancouver
O, Miriam	DFO Science OSD
O'Donnell, Kerrie	Ecotrust Canada
Park, Laura	DFO Oceans, NL
Pearsall, Isobel	DFO South Coast, Nanaimo
Perry, Ian	DFO Science MEAD
Robinson, Cliff	Parks Canada

Royle, Krista	Parks Canada
Samhouri, Jameal	NOAA, Seattle
Sandgathe, Tracey	DFO FAM, Vancouver
Saunders, Mark	DFO Science SAFE
Simpson, Jennifer	DFO OHEB SARA
Smith, Jo	Marine Planning Partnership for the North Pacific Coast
Templeman, Nadine	DFO Science, NL
Therriault, Tom	DFO Science MEAD
Thompson, Jason	Haida Oceans Technical Team
Thorpe, Hilary	Parks Canada
Trudel, Marc	DFO Science SAFE
Turris, Bruce	Fishing Industry
Wallace, Scott	David Suzuki Foundation
Wong, Cecelia	Environment Canada, Vancouver
Worcester, Tana	DFO Science, BIO
Workman, Greg	DFO Science MEAD
Wright, Kim	Living Oceans Society

APPENDIX D: WRITTEN REVIEWS

Reviewer: Laura Park, Fisheries and Oceans, Newfoundland Region

Working Paper: O, M., Martone, R., Hannah, L. Greig, L., Boutillier, J., and Patton, S. An Ecological Risk Assessment Framework (ERAF) for Ecosystem-Based Oceans Management. CSAP Working Paper 2012/P46

General Comments

This ERAF represents considerable work and presents some valuable and innovative elements. The approach is hierarchical, allowing the greatest effort to focus on VECs and stressors of greatest ecological concern, while providing rapid preliminary results to guide on-going risk management while more detailed assessments are being conducted.

Some steps in the Scoping Phase require further guidance or modification (see comments below).

A core feature of this method is the development of a series of tables (3, 6, 7, 10, 11, 12 and 13) which provide scoring guidance for the various factors and sub-factors. Recognizing that it is very difficult to produce clear and concise guidance that is specific enough to be useful and at the same time applicable to a broad range of diverse ecosystem components and stressors, the authors have done a commendable job. As the method is utilized there may be opportunities to expand these tables to accommodate components (such as phytoplankton) which may require additional guidance. These tables easily lend itself to the addition of new attributes and would be and interesting topic for group discussion.

Several steps of the framework rely on POEs. As long as all of the required POEs are available, this has the benefit of utilising ready-made, standardized, broadly accepted, nationally consistent, and ideally peer-reviewed models. The inclusion of a template or TOR for collecting supporting information for POEs would allow the method to be applied consistently in the absence of all of the required POEs.

The authors recognise the danger of screening out numerous low level stressors which in fact contribute to significant cumulative effects (*the nibbling effect*). They have made efforts to mitigate this by allowing extreme cumulative scores in Level 1 to be considered for a Level 2 assessment, even when scores for all individual stressors are low. Stressors that are weakly associated with a wide range of activities may also be under-estimated when the method assesses each Activity-Stressor pair individually. See comments under Level 1 below.

Specific Comments

Scoping: Phase 1 - Identification of VECs

The point of this step is to select a relatively short list of VECs which are of greatest ecological significance to the area being assessed.
The method fails to provide clear guidance/screening criteria for scoping habitats and community/ecosystem properties- Table 4 simply provides a habitat classification scheme. Similarly there is little guidance on how to select Community/Ecosystem Properties of ecological significance to the area, just a definition and some examples in section 2.1.1.2.

General (page 4) and specific (Table 3) criteria **are** provided for screening Species, and with some modifications these criteria could be used to screen Habitats as well as Community/Ecosystem Properties. This would reduce the number of steps and ensure that adequate guidance is provided for all VECs, recognising that species are likely to be the most common type of VEC.
Criteria developed to score Ecosystem Sensitivity for individual VECs (2.2.2.2.8) may also provide valuable guidance for the initial screening of the VECs and assist in the development of appropriate screening criteria.

Scoping: Phase 2 - Identification of Activities/Stressors
This step identifies the activities/stressors of greatest concern to the area

The method utilizes a Generic POE developed for each relevant activity within the area. See general comments above related to use of POEs.

Level 1- Rapid Preliminary Assessment to identify VECs and activity/stressors that require enhanced management attention and warrant further assessment.

Level 1 has 3 basic steps as outline below:
Based on qualitative information, scientific literature, and expert opinion, each activity and associated stressor identified in the Scoping Phase is scored as present or absent in relation to its interaction with each VEC as outlined in Table 5. A short rationale is provided to justify each score. This step provides a unique list of key Activities and associated Stressors for each VEC
Area-specific POEs are used to illustrate relationships between each VEC and key Activity/Stressors
A rapid assessment facilitated by a scoring rubric provides preliminary scores to assist managers in identifying VECs and Activity/Stressors of greatest concern, and screens out low-risk Activity/Stressors to allow the more intensive Level 2 assessment to focus on the analysis of higher risk Stressor-VEC interactions.

Comments:

Step 1
Table 5 is used to identify Activities and associated Stressors that may potentially be harmful to a specific VEC. Some stressors are strongly associated with one specific activity (for example ship strikes to marine mammals) while other Stressors (climate change, oil and other chemical contaminants, nutrients, litter/persistent plastic particles) can be associated with numerous different Activities. This means that the same Stressor can be identified numerous times in association with different Activities as shown in the example below (oil pollution resulting from various activities):

Activity	Stressor
Vessel Traffic	Physical strike by hull or prop
	Disturbance
	Oil pollution (Discharge of Oily Bilge, Refuelling spills, accidents/sinking)
Offshore oil development	Oil pollution (major blow out, minor leaks)
	Drilling muds
	Habitat damage from glory hole excavation
Oil transhipment	Oil pollution (Loading/unloading spills, tanker accidents/sinking, Oily ballast water discharge)
Municipal operations	Oil pollution (Oily storm drain discharge)
Land transportation	Oil pollution (Oily road runoff)
	Oil pollution (tanker truck accident)
	Noise
	Exhaust emissions
	Lights
Coastal Oil storage (tank farms)	Oil pollution (structural failure, human error, earthquake, terrorist attack)
	Degraded viewscape
Air traffic	Oil pollution (Fuel dumping, crash)
	Noise
	Exhaust emissions

If each of Activity/Stressor pair is considered separately, there is a danger of underestimating the stressor by dismissing (or screening out) many of the numerous minor sources. Although it is vital to identify the linkages between the Stressor and the Activities that we ultimately manage, if a Stressor appears more than once (in association with different Activities) there may be value in conducting a single assessment (score) for the Stressor. Alternately one could consider a broad group of Activities such *greenhouse gas production* or *discharge of oil* which captures all of the sources of the Stressor. This approach also avoids the duplication of effort which is required if the same Stressor is assessed numerous times.

Step 2
Scores are calculated to rank the level of risk for each Stressor-VEC combination based on the product of two factors, **Exposure** (a measure of the level of interaction [intensity, spatial/temporal scale] between the stressor and the VEC) and **Consequence** (level of harm). Scoring rubrics (1-6) are provided to guide the rapid scoring of each factor (Tables 6, and 7), resulting in a possible total score of 1-36 for each Activity/Stressor-VEC interaction –Scores ranging from 7-36 are considered moderate to high and these activity/stressors should be considered for a more detailed Level 2 Assessment.

Scores for each Stressor are added for each VEC to provide a preliminary risk score for each VEC (Table 9). VECs with an overall score of 20 or higher are considered for more detailed Level 2 Assessment even if the individual scores for each stressor are less than 7. Uncertainty scores are also recorded and can be used to justify a Level 2 Assessment even if Risk scores are low. This is appropriate use of the Uncertainty scores as long as common sense prevails and it is not used to inflate the importance of a range of minor Stressors that have not been well studied because there is no indication that they cause significant harm.

I like the scoring rubrics because they allow a rapid assessment based on clearly defined criteria, backed up with a short rationale which provides transparency. The difficulty with these types of scoring tables is that it is very difficult to develop one that works well for diverse group of stressors and VECs, and selecting an appropriate score is not always straight forward. For example if the Stressor is oil pollution, the worst case scenario would be a catastrophic spill – This type of event would be very rare, but if it did occur the intensity and spatial scale would be high/ widespread (score of 5). At the same time chronic small oil spills may be widespread and frequent, but of low intensity (score of 3?). Experience gained through using the method will assist in improving these scoring tables.

Level 2- Semi-quantitative Assessment of High Priority Stressors and VECs

2.2.2.2 Assessment of (relative) risk
This analysis is a semi-quantitative version of the Level 1 Assessment of risk = Exposure x Consequence which is detailed in 2.2.2.2.4 and 2.2.2.2.5

Exposure is a product of % area overlap, % depth overlap, % temporal overlap, and intensity with each factor scored on a scale from 0 to 10 (except for intensity which is scored from 1-10? [p24]). The product is then divided by 1000 to produce a score from 0 to 10. A scoring guide is provided (Table 10) as well as some written guidance to assist in scoring in the absence of quantitative information.

This computation is generally consistent with other risk assessments and should provide a reasonable estimate of relative risk, as long as common sense is used – If the final scores do not make sense (or differ significantly from the Level 1 results), they should be reviewed to find the source of error. Some general points to consider include:
Because these are relative scores, all Stressors need to be treated equally, particularly when comparing data-rich Stressors-VEC interactions (i.e. fishing/targeted species) to data-poor Stressors/VEC interactions (ghost nets/SARA species). See comments on % Area Overlap below. Alternately Level 1 can be used to produce the relative ranking and Level 2 can focus on providing the most detailed analysis possible with the available information.
Table 10 is provided as guidance for scoring in the absence of quantitative information. This Table should be used as a yard stick for all scores to offset the tendency to underscore data-rich Stressor/VEC interactions where more quantitative analyses are possible. See comments on specific factors below.

It is not clear to me how (if) uncertainty scores affect Risk scores within this ERAF. Page 24, end of paragraph 2, states *In the absence of information, evidence or logical argument to the contrary, a precautionary approach is recommended and risk should be set high.* Again on page 34 (3.3.2) it states *VEC-stressor combinations with high uncertainty scores are captured as higher risk in the framework in order to be precautionary.* As a general rule, high risk Stressors have been well studied. Therefore lack of information should not be a *carte blanche* justification for setting Risk high – this will just bias the results in favour of poorly understood (and possibly insignificant) stressors. Exceptions may relate to emerging issues known to be high risk Scientific uncertainty should be considered separately to allow the ready identification of subjects in urgent need of further research, and provide a sense of the reliability of the various analyses.

Some comments on specific factors:

Calculating Exposure

% area overlap
Application of this element appears straightforward when based on geographic information, however, it is not clear how probabilistic distributions such as those obtained from potential oil spill fate modeling for example, should be scored.

Even when dealing with geographic information it is important to use the same level of detail for all analyses so that the **relative** results are reliable. This means using a semi-quantitative approach to all analyses rather than trying to mix highly detailed quantitative analyses with fuzzy broad brush approaches. For example if we only have a range map for a species we may say it occupies
100% of the area
but if we also know the depth range for the species and have bathymetry for the area we may be able to calculate that it actually occupies only 13.6% of the area.

Similarly if we know the entire area is open to bottom trawling we may say the area covered by the Stressor is
100%

But if we also have detailed information on the Stressor (100 trawlers conduct 100 tows per year, and each tow covers an area of 25 km^2 within the 2,500,000 km^2 area being assessed), one could do the math and say the % of the area trawled is
d) 10%

So in this example differences in the amount and use of data can result in a score between 10 and 0.1 and this is just for a single factor.

Intensity
There is a danger of redundancy between the scoring of Intensity and the other exposure factors. For example fishing effort is a product of the length of the season, the number/density of vessels, the amount of gear /vessel, length of tow (for mobile gear) etc. It is important to ensure that none of these factors are considered twice since this could artificially reduce the score. For example the length of season is considered in % Temporal Overlap and should not be considered in Intensity. Likewise if a very detailed analysis of vessel positions/tow length is used to calculate % Area of Overlap (as opposed to the general area where fishing may occur), this information should not be used again to score Intensity.

Intensity is a relative term. Park et al. (2010) use a global maximum or worst case scenario as a yardstick with which to judge the current level of intensity in the local area of interest. This helps to prevent redundancy with the other factors, provides consistency from one area to the next, and introduces a common reference point to ensure that diverse stressors are scored fairly in relationship to each other. This method adopts this feature with one improvement: In Level 1, Intensity is scored **at the level of** a plausible worst-case scenario (catastrophic oil spill) ensuring that potentially catastrophic stressors are bumped up to a level two assessment even if their likelihood of occurrence is extremely low. Then in Level 2 Intensity is scored **relative to** an estimated worse-case scenario similar to the method of Park et al (2010).

Calculating Consequence

Tables 11 - 13 provide helpful guidance which should promote consistent application of the analysis. Table 11 will work well for most VECs (fish, marine mammals) but not so well for lower species (plankton, krill) and some additional guidance may be useful or perhaps they are best scored as community properties.

You may want to consider averaging the scores for Acute + Chronic Change (see comments below).

Calculating Relative Risk

Risk is defined as Exposure x Consequences. Exposure is the product of 4 separate factors (each scored out of 10) with the total normalized to produce a score from 0 to 10. In contrast, Consequence is calculated by adding 2 factors and then multiplying the sum by the third factor and all factors are scored on a scale of 1-3. Possible Risk scores range from 0 to 180 but most scores will be less than 60 and many will be quite low.

This equation gives more weight to Exposure than to Consequences simple by virtue of the math (this is also an attribute of the method developed by Park et al.):

$$\text{Risk} = \frac{(\%\text{Area} \times \%\text{Depth} \times \%\text{Time}) \times \text{Intensity}}{1000} \times (\text{AcuteChange} + \text{ChronicChange}) \times \text{Recovery}$$

For example in a scenario where all Exposure factors are low (3) and all Consequences factors are high (3):

Risk = 3 x 3 x 3 x 3/1000 X (3+3) x 3
Risk = 0.081 X 18 = a score of 1.46 (very low)

Whereas in a scenario where all Exposure factors are high and all Consequences factors are low:

Risk = 10 x 10 x 10 x 10/1000 X (1+1) x 1
Risk = 10 X 2 = a score of 20 (medium-low)

As long as all Stressors/VECs are treated equally this is not a fatal flaw, but an equal treatment would be ideal. This could easily be done for this method by a few simple changes to the equation:

For Exposure:
Select one score out of 10 for PExposure based on an examination of the three factors (%Area x %Depth x %Time) in Table 10. This would be similar to the method used to select a single score for Recovery from a series of attributes in Table 11-13.
Then multiple by Intensity (scored out of 10). Divide by 10 to normalize to a score out of 10.

For Consequences:
Score each factor out of 3, but take an average value for Acute and Chronic Change and then multiple by Recovery for a score out of 9. This will give roughly equal weight to both elements:

For example in the scenario where all Exposure factors are low and all Consequences factors are high:

Risk = 3 x 3 /10 X (3+3)/2 x 3

Risk = 0.9 X 9 = a score of 8.1 (low)

Whereas in the scenario where all Exposure factors are high and all Consequences factors are low:

Risk = 10 x 10 /10 X (1+1) x 1
Risk = 10 X 1 = a score of 10 (low)

To produce identical weightings, simply score all factors on the same scale.

Another aspect of the equation worthy of note is that the scoring of Exposure allows a nil value whereas the scoring for Consequences does not. This means that an overall score of nil can only result from an analysis of Exposure but not Consequences. Since all of these interactions have already gone through the scoping phase, this should not be problematic - a maximum score of 10 (out of a possible 180) will result if all Consequences are scored as low (1) and any interaction that has been screened in will presumably have at least some level of risk associated with it.

For the Level 1 assessment Table 8 provides a scale (Negligible to Extreme) for the final risk Scores. A similar table would be useful for the Level 2 Risk scores.

2.2.2.2.8 ERisk (Reflects the importance of the VEC to the Ecosystem)

This method diverges from Park et al. (2010) by considering this factor as a separate step. I consider this a significant improvement since the ERisk is unrelated to the other factors, and is an important consideration for oceans managers which may be lost within the total score.

Two approaches are provided, with approach #1 considering both the cumulative risk to the VEC, and the sensitivity of the ecosystem to the loss or degradation of the VEC, to provide an index of the relative risk to the ecosystem for each VEC. This approach allows assessors to rank VECs based on the risk to ecosystem health associated with their interaction with key stressors, and focus management actions accordingly.

Approach # 2 examines the potential risk to ecosystem structure and function, by examining the cumulative impacts to defined aspects of ecosystem structure and function and would provide guidance on ecosystem attributes that may be at risk to guide appropriate mitigations.

Both approaches have value and will provide useful information to inform oceans management planning. The analysis of the sensitivity of the ecosystem to the loss or degradation of each VEC may also have relevance to the Scoping Phase (identification of VECs of ecological significance to the area).

Level 3 Quantitative Assessment

In my comments on the Level 2 Assessment, I discussed some of the dangers in trying to combine quantitative analyses (when very detailed spatial data is available) and qualitative analyses to produce a relative ranking – The ranking tends to underscore the components which undergo a quantitative analysis relative to the qualitative approach. An unbiased approach tends to require a qualitative approach overall, essentially ignoring much of the detailed quantitative spatial data. However, once the relative ranking has been established (either in Level 1 or Level 2) it is no longer necessary to conduct **relative** analyses and all available data can then be used to conduct more quantitative assessments on individual or related groups of components to guide specific objectives, strategies, and actions within the management area.

Reviewer: Jameal Samhouri, Conservation Biology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration

Working Paper: O, M., Martone, R., Hannah, L., Greig, L., Boutillier, J., and Patton, S. An Ecological Risk Assessment Framework (ERAF) for Ecosystem-based Oceans Management. CSAP Working Paper 2012/P46

Overall, the ERAF introduced in this working paper builds nicely on approaches developed by government agencies in Australia and the US, in addition to those produced at academic institutions. I strongly agree with the hierarchical framework that allows for risk assessments in data-constrained and data-rich situations. Indeed, this feature makes it very scalable and as useful for small MPAs as it is for larger areas like PNCIMA. It is also an adaptable framework that should allow integration of additional information as it becomes available in any specific application. My concerns and suggestions for improvement appear below, beginning with cross-cutting conceptual issues and followed by specific comments about VECs, POEs, and Level 1 and 2 risk assessments.

Key points
This ERAF will not get decision makers as far as prioritization of management actions, nor can it alone serve as a decision-making structure. It will, however, highlight threats that pose the greatest relative risk to valued ecosystem components. To prioritize action and guide decisions, that information will have to be ingested in the context of societal preferences for different VECs; costs of alternative actions; potential return on investment for different actions; and, calibration to absolute levels of risk. The cost-effectiveness analysis presented by Carwardine et al. (2012) in Conservation Letters is a nice example of how to do this.

I suggest treading cautiously with the assessment of cumulative risk. Scientific understanding of interactions between stressors is poor. While a simple default assumption is that interactions should be additive and there are papers that back this assumption up (Crain et al. 2008), it is definitely not always the rule (e.g., Jackson et al. 2001 Science argue that overfishing predominates and predates all other anthropogenic influences in the marine environment). I very much like the idea of estimating cumulative risk based on both additive and non-additive interactions, in order to contextualize the overall cumulative risk assessment. Stelzenmuller et al. 2010 MEPS provide one example of how to do exactly that. However, such an analysis should still be heavily caveated. There is also a lot to be gleaned by assessing risk due to individual stressors on the VECs, and I would hate to see that effort undermined by a misleading assessment of cumulative risk. For example, comparison of relative risk from different stressors to an individual VEC is informative, as is clustering of all stressors at high risk for any single VEC. One need not sum risk scores to obtain these insights—several graphical methods are available.

Where possible, it might be better to associate a level of uncertainty with each piece of a Level 1 or 2 risk assessment. It is useful to know answers to the questions in Appendix C, but for each term in the risk score (e.g., for QExposure and QConsequence individually for Eqn 1; in Table 6, for intensity, temporal scale, and spatial scale). Fuzzy logic and Bayesian approaches provide a way forward for formally incorporating uncertainty in the risk score.

As the authors explain, risk can be estimated from 2 axes of information in a variety of ways. They mention the product of exposure and consequence vs. a Euclidean distance calculation in particular. Note that the maximum risk score calculated from Exposure and Consequence axes is not equivalent using a product vs. Euclidean equation. This fact makes the comparison in Appendix F somewhat misleading. In addition, it is not the case that one approach is always

more or less conservative than the other. When exposure and consequence are very different, risk calculated using the product of E and C will be lower than if it were calculated using the Euclidean distance equation. When E and C are very similar, risk calculated using the product of E and C will be higher than if it were calculated using the Euclidean distance equation. This disparity will be particularly apparent when values of E and C are both high.

The authors might consider a treatment of the sensitivity of their risk equations to reliance on few versus many subterms. See further comments below.

Calibrating ERAF relative risk to a measure of absolute risk is challenging. Therefore the idea presented in Section 2.2.1.1 of having a unique list of activities and stressors for each VEC may limit the scope of inference. Having a common list of activities and stressors assessed for all VECs may be preferable.

I think the authors should strive to be more explicit in defining scoring rubrics in Tables 6, 7, 13, B1-B3. The scoring rubrics need better qualifiers. What is "rare?" What is a "minimal impact?" While data will not always be available to populate the scores, it is important to be sure that scoring is done in a consistent way across VECs, regional applications, etc.

Actually providing worked examples of a Level 1 and Level 2 risk assessment for a couple of VECs would improve transparency and ensure workability of these approaches.

Specific comments about VECs, POEs, and Level 1 and 2 risk assessment
VECs. I think Tables 3-4 and the related *Community/Ecosystem properties* section are a reasonable approach to selecting ecosystem components on which to focus the risk assessment. However, I don't think that these guidelines address how to put the 'V' in VEC. That is, the notion of a *valued* ecosystem component suggests that someone (presumably stakeholders or their representatives?) exhibits preferences for some ecosystem components but not others. Indeed, in Figure 2 and on p. 8 the authors suggest that the initial list of ECs is compiled based on a survey of such preferences. I think it is worth considering a final step, following the screening step illustrated in Fig 2, using the guidelines in Tables 3-4 and the related *Community/Ecosystem properties* section, to ensure that societal preferences are adequately represented in the final set of VECs selected for the risk assessment.
I would suggest that the text recommend the construction of a table populated with short justifications and/or citations next to each selected VEC. Also see criteria and approach in Kershner et al. 2011.

Table 3: The "sensitive species" criterion seems to create a bit of circularity—isn't determining sensitivity of species one goal of the risk assessment? In addition, it seems like all exploited/targeted species could be considered VECs as they have a market value etc. etc. And what about 'iconic species?'

Table 4: I think the text could use a little bit more explanation on how to use these criteria. For example, how does one choose between abiotic and biotic habitats after using these filters? Or, are all living habitats considered species for the purpose of this ERAF?

POE models. I generally like this idea and agree that it is important to outline the ways in which different activities create stressors on VECs. I like the idea of a virtual library of POE models. POEs are reminiscent of DPSIR models, so perhaps that literature should at least be referenced.

I imagine that development of POEs will often be guesswork as many of the mechanistic links will not be well understood or established with empirical data.

Can the POEs incorporate (a) natural drivers that create stressors, and (b) indirect effects? As an example of indirect effects, in Fig. 4, wouldn't it be possible that a change in contaminant concentrations would cause lethal or sublethal effects on fish? As the figure is drawn, only changes in particle velocity and pressure affect fish. Similar problem occurs on Fig 6, where contaminants could affect rockfish reproductive capacity.

Level 1 qualitative risk assessment. This approach is akin to work in fisheries developed by Fletcher (2005) and the SICA methodology developed by Hobday et al. (2007). It is generally sound. However, I found the organization and explanation of the approach challenging to follow because of the many sub-steps and sub-scoring procedures. A variety of conceptual and technical comments appear below.

Equation 1: QExposure relies on an understanding of 3 subterms (intensity, temporal scale, and spatial scale). For each VEC, for which subcomponent should these subterms be scored?
Equation 1: The score for QConsequence is based on a single criterion. (Note that it was very hard for me to figure out the relationship between Table 2 and the tables in Appendix B, but I got there eventually). Scoring QConsequence based on a single criterion will cause QRisk to be more sensitive to the QConsequence score than the QExposure score. Is that the intent? An alternative idea that would reduce the sensitivity of QRisk to QConsequence alone would be to separate out resistance and recovery subterms in evaluating QConsequence for each subcomponent.

Equation 1: The authors recommend that QConsequence should be scored based on the subcomponent that is most affected by the stressor. How is that determination made? For example, if rockfish population size and reproductive capacity are both affected by a stressor, as depicted in Fig 6, how does one decide which subcomponent to score QConsequence on? On p19, the authors recommend promoting VECs exposed to multiple stressors whose cumulative scores put them in the extreme category to the Level 2 risk assessment. What are the appropriate categories for distinguishing extreme cumulative risk from non-extreme? Should QRisk scores for individual stressors be summed, and if so, what are the risk categories for CumQRisk?

As described above, note that Equation 1 will not be precautionary (in comparison to a calculation based on Euclidean distance) when values for QExposure and QConsequence differ substantially. However, it will be precautionary when QExposure and QConsequence have similar values, especially if those values are large.

Equation 1: should QExposure and QConsequence always receive the same weight in a risk calculation?

As described above, I think it would be more effective to generate an uncertainty rating for term and subterm of Equation 1, and using those ratings to conjure an uncertainty score for QRisk as a whole.

On p.34 the authors imply that the necessity of a Level 1 risk assessment may be scale-dependent. My guess is that its necessity will be data-dependent, and that in some cases more data of appropriate resolution will be available at larger scales than at smaller scales. Such is the case in the US portion of the California Current LME.

Level 2 semi-quantitative risk assessment. This approach is very much in line with work that I have done (Samhouri and Levin 2012), which has its roots in papers published by Stobutzki et al. (2001), Hobday et al. (2007), Patrick et al. (2010), and Tallis et al. (2011). I found the organization and explanation of the approach a bit challenging to follow, in part because sections 2.2.2.2.4 and 2.2.2.2.5 really flesh out how equation 2 works, but appear pages after Equation 2 is introduced. I would suggest moving Equations 3 and 4 farther down in the text. A variety of conceptual and technical comments appear below.

Equation 2: Exposure is scored on a scale of 0-10, based on calculations made using Equations 5-6. Equation 5 assumes PExposed and Intensity have equal weight in determining Exposure. Thus, scores for Exposure, will be highly sensitive to values of PExposed and Intensity and associated data quality. However, PExposed is composed of the 3 subterms described by Equation 6. The authors could use a geometric mean to give all 4 subterms (% Area overlap, % Depth overlap, % Temporal overlap, Intensity) equal weight, reducing the sensitivity of Exposure in Equation 5 to each subterm individually. Alternatively, it would be good to provide a justification for the assumption that PExposed and Intensity subterms should have equal weight.

Equation 2: should Exposure and Consequence always receive the same weight in a risk calculation?

Equations 5-6: I like the idea of including Table 10 for cases where quantitative data are not available. The use of the 75% point through the range for each attribute seems a bit arbitrary, and does not capture uncertainty. Also, what is the justification for different percentile categories in Table 10 as compared with those used for acute and chronic change in Table 11?
Equation 5: I think the guidelines for scoring Intensity need to be fleshed out a bit more. The authors should define the universe for scoring—what is meant by "scoring is relative to an estimated worst-case scenario?" Is intensity a % of the global maximum? When and how might quantitative information be available for scoring Intensity without the aid of Table 10?
Equation 7: As with exposure, giving acute change and chronic change equal weight increases sensitivity of consequence score to data quality because there are only 2 bits of information that matter (sum of acute and chronic change, and recovery). In addition, in contrast to all previous equations and subterms in the Level 1 and 2 approaches, the Recovery term is going to be enormously insensitive for each VEC because so many factors are used to score it. Note that some (many) of these factors are likely to be collinear (e.g., age at maturity and natural mortality rate).

Equation 7: Table 11 should also refer to papers by Stobutzki et al. (2001) and Cheung et al. 2005.

Equation 7, Table 13: The factors selected in this table serve well as examples, but if they are to be used moving forward it seems like some vetting procedure to avoid redundancy and ensure availability of evidence will be necessary. For example, the "% of functional groups impacted" will likely be correlated with the "% of species impacted."

Equation 3: As I mentioned above, determining what is the appropriate way to calculate cumulative risk is nontrivial. I personally might find the disaggregated risk scores calculated from Equation 2 more valuable than those calculated using Equation 3. The scenarios presented by Stelzenmuller et al. 2010 MEPS would serve as a reasonable reference for justifying the proposed approach.

Equation 4: An attempt to estimate ecosystem risk is a clever idea, and I can see why in theory it would be based in part on cumulative risk. However, it seems like it would also be valuable to

understand ecosystem risk as influenced by individual stressors. Also, ESensitivity strikes me as difficult to score across all VECs. I could see how it might be scored for a set of species or a set of habitats, though. In fact, in some ways, ecosystem risk may be best assessed from understanding risk to community/ecosystem properties, no? In any case, the general idea of estimating Ecosystem Risk is great, how to execute it will require some more development.
I understand the approach proposed in Equation 9 for estimating ESensitivity, but Equation 10 is less clear-cut.

Appendix C: I would suggest that empirical data and published models are both superior to anecdotal information and probable scenarios. I'm not sure why recent data should be favored over good data from >10 years ago. The last 2 questions strike me as redundant.
As highlighted by the authors, neither the Level 1 nor the Level 2 approach handle interactions between VECs well. For example, if risk to VEC X due to activity Y is high, that may modify risk to VEC Z due to activity Y.

How would one determine which VECs warrant a Level 3 assessment? Is there an a analog to Table 8?

Reviewer: Phillip Levin, NOAA

Working Paper: O, M., Martone, R., Hannah, L., Greig, L., Boutillier, J., and Patton, S. An Ecological Risk Assessment ERAF (ERAF) for Ecosystem-based Oceans Management. CSAP Working Paper 2012/P46

Thank you for the opportunity to review this document. I am sorry I can't be there for the workshop.

This document lays out a risk assessment ERAF for the PINCIMA region. The document is well-written, and well-grounded in the modern EBM risk assessment literature. Overall, I think the ERAF presented here will be an advance over the work I'm familiar with in the US and in Australia. It is really difficult to evaluate the ERAF in the absence of a detailed worked example; nonetheless, I see nothing here that would cause me to hesitate trying out this ERAF. I'm sure workshop participants will have a number of good suggestions, and I'm also sure that trying to use the ERAF will cause practitioners to improve the ERAF.

All in all, this is an interesting ERAF that is an incremental improvement over existing approaches. I look forward to its use.

In addition to some scribbles I've made on the document itself, I provide these general comments:

For a reader not embedded in the Canadian system, it was fairly difficult to determine exactly where / how the risk assessment ERAF here fits into a larger EBM picture. Perhaps this is obvious to most readers of this, but I was left wondering what the context was for this work.

Human dimensions. Throughout, I was surprised to see (nearly) only human portrayed as the agents of threats. This seems at odds with the present emphasis in marine conservation on ecosystem services. I think it is really difficult to think about EBM without considering risk across all EBM sectors. E.g., what are risks to the economic, social or cultural well-being of coastal communities. It was not clear why there was a sole focus on ecological attributes.

Without a risk analysis that covers both the human and natural components of the ecosystem, it would really seem difficult to fully use this work in a management context. Luckily, I think the framework could easily be adapted to human dimensions, and I would urge the authors to consider this. I imagine this might require some expertise outside of the author group, but I think it would be worth the effort. And, while the data or resources might not be available to complete a risk assessment for the human dimensions of the ecosystem, I think beginning the process is important.

I like the concept of VEC, and I think the general framework outlined in to document to identify VECs is good. However, it seems that VECs are to be identified outside of a scoping process. To what extent will stakeholders be brought into the VEC process? This seems like a good opportunity for stakeholder input, education and outreach.

Unacceptable risk. This term was not defined, and to me it is the key to implementation. How will reference levels and benchmarks be established? In their absence, how does one know how much risk is too much?

The POE framework is quite similar to DPSIR framework common in Europe. It is also very similar to the "open standards for conservation" It would be worth exploring similarities and lessons among these approaches.

I was surprised to see very little formal role for stakeholders or first nations in the VEC process. And this came up for me again when the notion of EBM objectives was raised on pg 13. How are broad, societal objectives determined? How and who determines them?

In a number of places I wrote (and in other places I thought...) it would be nice to have a much more detailed and technical explanation of the methods. For example, I think a careful consideration of the consequences of certain choices in the risk calculations would have been nice. I liked the short explanation of why the E and C were multiplied instead of using Euclidean distance. However, why not only possible formulations? There are lots of different ways to combine these numbers, each with different pros and cons depending on how you want the index to behave.

Have you considered using formal Bayesian Belief Network modeling to conduct level 1 analyses? Might be worth doing (and could be a way to fully engage regional experts and stakeholders and first nations).

Data. A discussion of data sources, limitations, etc. would be nice. How realistic is it to actually do this?

I think the POE's are a very useful approach. However, to what extent does this lead to compartmentalization of issues, rather than a more integrated approach. That is, to what extent do POEs interact with each other? Or, are there examples where more than one activity is built into a single POE?